RELATIVE ABUNDANCES OF *PSEUDOMYRMEX SPINICOLA* AND *P. FLAVICORNIS* COLONIES IN *ACACIA COLLINSII* TREES UNDER DIFFERENT AMOUNTS OF CANOPY COVER

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Abstract. We examined the distribution of acacia ant species (*Pseudomyrmex* spp.) under different canopy conditions. We found a change in the relative abundance of *P. spinicola* to *P. flavicornis* and to all other acacia ant species depending on amounts of canopy cover. To test whether differences in ant thermal tolerance may contribute to the observed *Pseudomyrmex* spp. distribution pattern, we subjected *P. spinicola* and *P. flavicornis* individuals to increasing ambient temperature in the lab. Although sample sizes were small, our results suggest that the thermal tolerance of *P. flavicornis* is higher than the thermal tolerance of *P. spinicola*. We propose that this apparent difference in thermal tolerance may lead to different competitive abilities between the two species of ants.

INTRODUCTION

Acacia collinsii trees have an obligate mutualistic relationship with acacia ants. *A. collinsii* can be colonized by one of several species of acacia ant. Janzen (1983) suggests that *Pseudomyrmex flavicornis* occupies acacias more frequently in open sun while *P. spinicola* occupies acacias across all levels of canopy cover. To test this prediction, we compared the relative abundance of *P. flavicornis* to *P. spinicola* in areas with different amounts of canopy cover.

Ambient temperature increases as canopy cover decreases and exposure to direct sun increases. If the abundance of *P. flavicornis* to *P. spinicola* increases with decreasing canopy cover, it follows that *P. flavicornis* are exposed to a higher average ambient temperature than *P. spinicola*. Therefore, we hypothesized that *P. flavicornis* would have a higher thermal tolerance than *P. spinicola*. We reasoned that this difference in thermal tolerance may contribute to the hypothesized differences in habitat distribution of the two species.

METHODS

We sampled *A. collinsii* in four belt transects east of the OTS Biological Station, Palo Verde National Wildlife Refuge, Guanacaste Province, Costa Rica. The first two belts, each 65m x 20m, were spaced 30m apart and extended from the main road south into the secondary forest. The other two belts, each 150m x 5m, extended east along the edges of the main road, one on each side. We placed each *A. collinsii* tree into a low, medium, or high canopy over class and recorded the species of colonizing ant.

To test the thermal tolerance of *P. spinicola* and *P. flavicornis* we collected ants from two *A.collinsii* under moderate forest cover. We used two pots in a double-boiler arrangement with approximately one liter of warm water (28°C) in the lower pot and added boiling water gradually. In each of three trials we placed ten ants of each species in individual vials in the dry upper pot, increased the water temperature and observed the ants' behavior. Our thermometer measured only up to 50°C, and most ants died at a temperature above that level. As a result, our thermal tolerance test was limited to a qualitative comparison of minimum and maximum thermal tolerance thresholds of each species. We defined a lower thermal tolerance level (LTTL) for each species as the temperature at which the first ant died, and an upper thermal tolerance level (UTTL) as the temperature at which 50 percent of the sample died in each trial (as in standard LD_{50} procedure).

TABLE 1. Number of acacia trees colonized by each species of ant under three categories of canopy cover in 4100 m^2 of dry forest at Palo Verde, Costa Rica. The relative abundance of *P. spinicola* and *P. flavicornis* varied significantly with the amount of canopy cover. The abundance of *P. spinicola* relative to all other species combined also varied significantly with the amount of canopy cover.

Species	Low Cover	Medium Cover	High Cover	Total
P. spinicola	10	24	34	68
Other				
P. flavicornis	7	1	8	16
P. nigrocincta	1	1	1	3
Paracryptocerus spp.	0	0	1	1
Crematogaster spp.	2	0	1	3
P. gracilis complex	0	0	1	1
Total other	[10]	[2]	[12]	[24]
Total	20	26	46	92

RESULTS

The relative abundance of *P. spinicola* and *P. flavicornis* varied with the amount of canopy cover (G=9.469, DF=2, P<0.05, Table 1). *P. spinicola* was more abundant than *P. flavicornis* under all three levels of canopy cover, but the relative abundance of *P. spinicola* to *P. flavicornis* dropped abruptly under medium to low levels of canopy cover. The highest relative abundance of *P. spinicola* to *P. flavicornis* occurred at medium levels of canopy cover (Table 1).

The abundance of *P. spinicola* relative to all other species combined (*P. flavicornis*, *P. nigrocincta*, *P. gracilis* complex, *Paracryptocerus* sp., and *Crematogaster* spp.) also varied with the amount of canopy cover (G=10.977, DF=2, P<.05, Table 1). *P. spinicola* was more abundant than all other species combined under high and medium levels of canopy cover, but *P. spinicola* was similar in abundance under low levels of canopy cover. The highest abundance of *P. spinicola* relative to all other species combined occurred under medium levels of canopy cover (Table 1).

In all three heat tolerance trials, the first ant to die was a *P. spinicola*. Five of 10 *P. spinicola* died in the first trial, three died in the second trial and four died in the third trial. Two of 10 *P. flavicornis* died in the first trial, five died in the second trial, and four died in the third trial. We observed that *P. spinicola* decreased in activity at temperatures above its LTTL while *P. flavicornis* actually increased in activity at temperatures above its LTTL. Thus, *P. spinicola* appeared to have a lower LTTL than *P. flavicornis*, but both species appeared to have a similar UTTL.

DISCUSSION

At higher levels of canopy cover with lower temperatures, where thermal tolerance is less important to ant function, *P. spinicola* maintains a strong competitive dominance over all other ant species combined. Since *P. spinicola* seems to be less active at high temperatures and to have a lower LTTL than *P. flavicornis*, *P. flavicornis* seems better able to tolerate high temperatures. Thus, under low levels of canopy cover where ambient temperatures are highest, *P. spinicola* may lose some of its competitive edge to *P. flavicornis*.

P. spinicola expends more energy on defense of the host plant because they remove more vegetation around their host tree than other species (Janzen 1983). Assuming healthier acacia trees provide higher energy rewards, *P. spinicola* will increase its net energy gains only when its added defenses contribute to plant health. In high light, where sunlight is less limiting, acacia trees may rely less on ant

defenses, and *P. spinicola*'s added defenses may contribute little to plant health. *P. spinicola* may lose part of its competitive edge under high light conditions because *P. flavicornis* and other acacia ant species that expend less energy on defense have higher net energy gains than *P. spinicola*.

Acacia trees survive and grow poorly under low light conditions (Janzen 1983). The added defense of *P. spinicola* may contribute little to acacia health where light is too low to support acacia growth and survival. *P. spinicola* may again lose some competitive advantage by having lower net energy gains than species that expend less energy on plant defense. Under moderate light conditions the added defenses of *P. spinicola* may increase plant health. In this intermediate range where *P. spinicola*'s added effort presumably leads to higher energy rewards from the tree, *P. spinicola* is most competitively dominant over all other acacia ant species.

LITERATURE CITED

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